

## **ATTACHMENT I**

**Conceptual Description for the Selected High Ozone Days in 2000-2007**

## Background

The following conceptual description for selected high ozone days in years 2000 - 2007 in the Maricopa County Nonattainment Area (MNA) follows EPA's *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM<sub>2.5</sub>, and Regional Haze* (U.S. EPA, 2007), section 11.1.1.

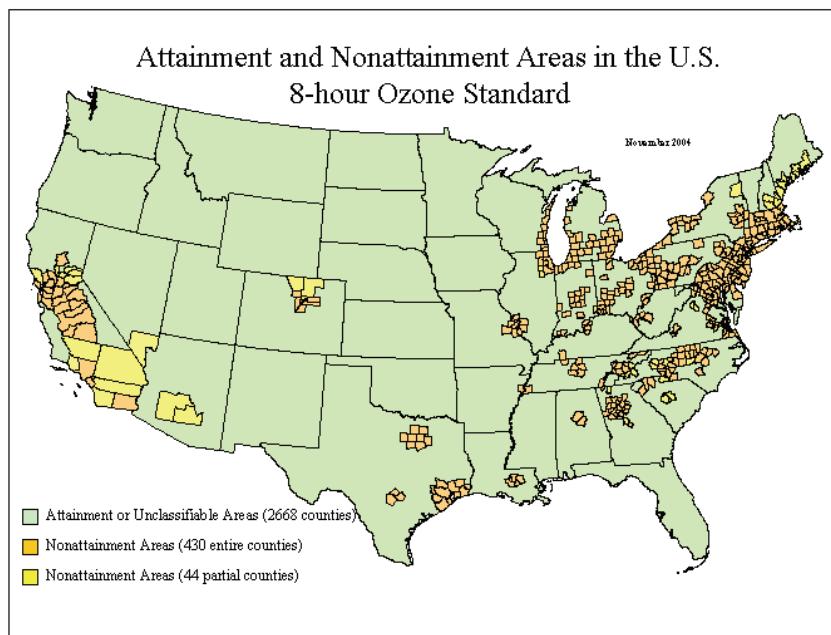
During the last three years (2005 - 2007), there was no violation of the eight-hour ozone standard in the MNA. The nonattainment period discussed in this conceptual description refers to the time period between 2000 and 2004. It is helpful to review the nonattainment records to obtain a better understanding of the eight-hour ozone problem in the MNA as part of the development of the eight-hour ozone maintenance plan.

Most of the supporting material in this conceptual description is from MAG's eight-hour ozone attainment plan (MAG, 2007). Tables, plots and text from the eight-hour ozone attainment plan have been updated and revised where necessary.

The following sections list questions and answers with supporting material regarding the eight-hour ozone in the MNA.

### 1. Is the nonattainment problem primarily a local one, or are regional factors important?

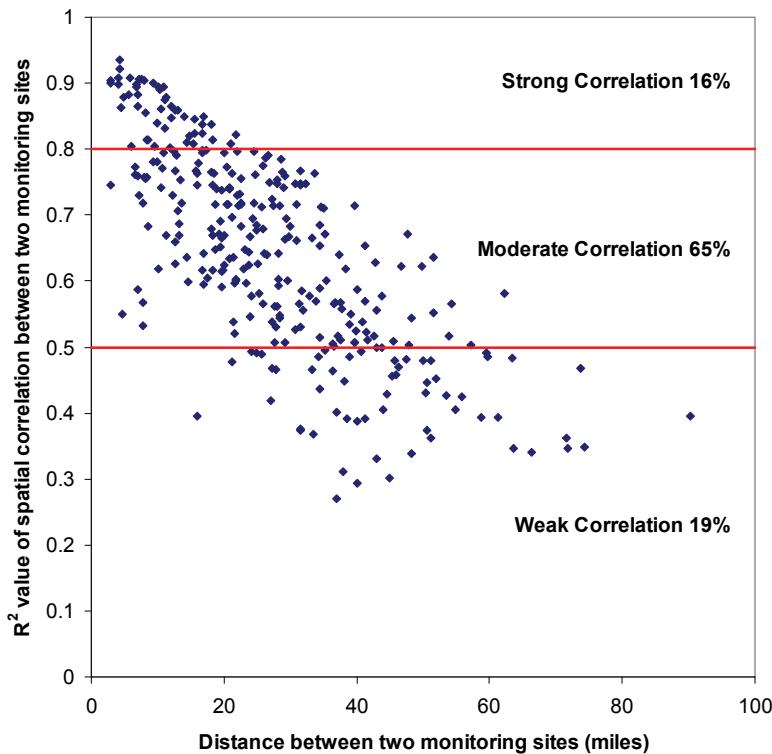
To answer this question, regional factors are checked first to see whether they are likely to be important. Figure 1 shows eight-hour ozone area counties in the U.S.



**Figure 1.** Eight-hour ozone area county map (source: U.S.EPA, <http://www.epa.gov/air/oaqps/greenbk/naa8hrgreen.html>)

The map in Figure 1 indicates that the closest eight-hour ozone nonattainment areas to the MNA reside in southern California. These nonattainment areas, however, are more than one day's transport to the MNA according to the back trajectory analyses of high ozone days in MAG's eight-hour ozone attainment plan (MAG, 2007). The majority of the 24-hour back trajectories on the high ozone days indicated that transport into the MNA originated from south-southwest of the MNA, from an area along the border of Mexico and the Pacific Ocean. This suggests that regional factors are unlikely to play a major role in eight-hour exceedances in the MNA.

Examining the relationship between the correlation coefficients of observed eight-hour daily maximum ozone and the distances of monitoring sites in the MNA provides additional evidence that regional factors do not play a major role in the MNA's eight-hour ozone exceedances. Figure 2 shows that most ozone monitors in the MNA have moderate correlation coefficients ( $R^2 \geq 0.5$ ), and the correlation coefficients of eight-hour daily maximum ozone are strongly influenced by their distance from each other. This suggests local factors are dominant in eight-hour ozone exceedances.



**Figure 2.** Relationship between distance and  $R^2$  value of ozone monitoring sites in the MNA

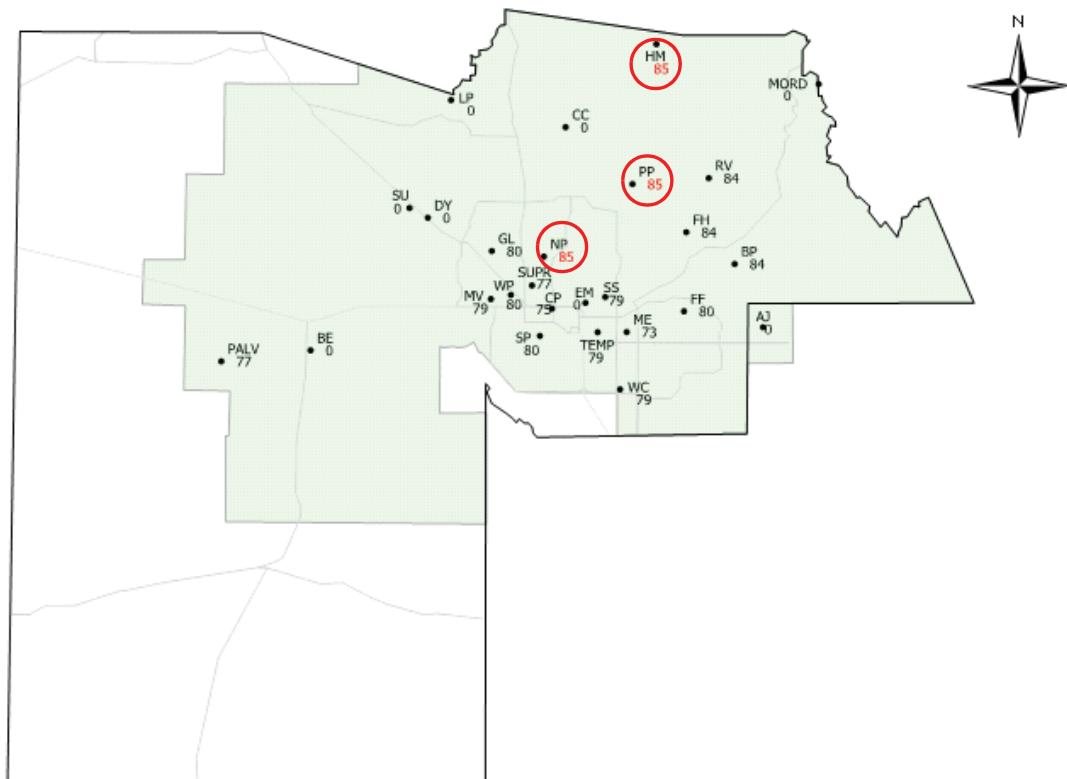
Further evidence supporting the importance of the role of local factors to the MNA's eight-hour ozone exceedances is provided in Sections 3, 5, 8 and 11. Thus, it can be concluded that the eight-hour nonattainment problem was primarily caused by local, not regional, factors.

## **2. Are ozone and/or precursor concentrations aloft also high?**

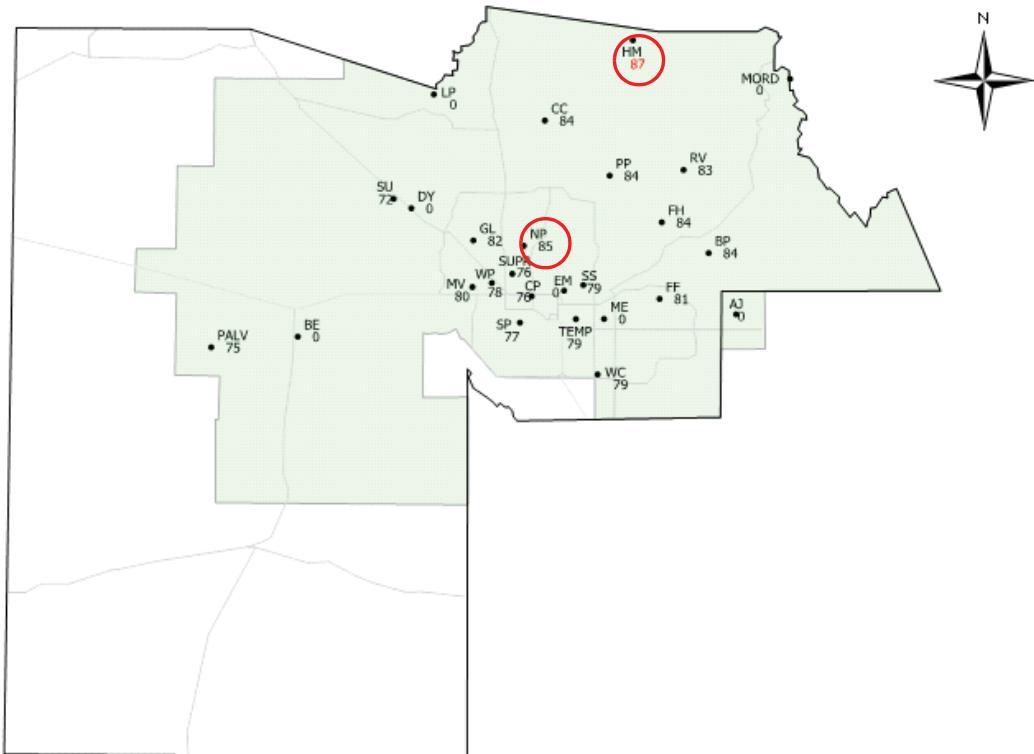
There are no such measurements available for the MNA.

## **3. Do violations of the NAAQS occur at several monitoring sites throughout the nonattainment area, or are they confined to one or a small number of sites in proximity to one another?**

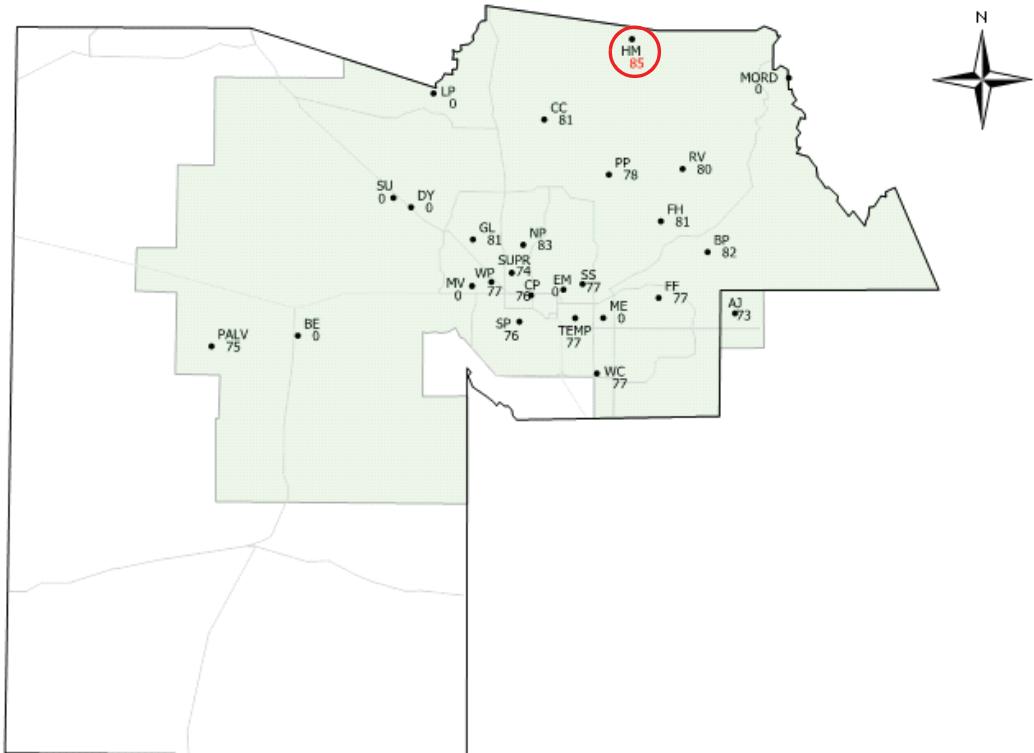
As shown in Figures 3.1~3, violations of the eight-hour ozone standard occur at a limited number of sites in proximity to one another. The number of sites having a violation decreased from three sites, during 2000-2002, to one site during 2002-2004. Humboldt Mountain is the only monitoring site that violated the eight-hour ozone standard for three consecutive periods (2000-2002, 2001-2003, and 2002-2004). There was no eight-hour ozone violation at any site during the next three periods of 2003-2005, 2004-2006, and 2005-2007.



**Figure 3.1.** Spatial distribution of eight-hour ozone design value during 2000-2002  
(Unit: ppb)



**Figure 3.2.** Spatial distribution of eight-hour ozone design value during 2001-2003  
(Unit: ppb)



**Figure 3.3.** Spatial distribution of eight-hour ozone design value during 2002-2004  
(Unit: ppb)

#### **4. Do observed eight-hour daily maximum ozone concentrations exceed 84 ppb frequently or just on a few occasions?**

The frequency of eight-hour daily maximum ozone exceeding 84 ppb varies among the monitors during the period between 2000 and 2007, as shown in Table 1. High ozone days with eight-hour ozone exceeding 84 ppb were observed at least once at most of the monitoring sites except for three sites, the Dysart, Surprise, and Buckeye sites. The Blue Point site had the highest annual total of eight-hour daily maximum ozone exceedances -10 days in year 2000. The eight-hour daily maximum ozone exceeded 84 ppb a number of times in year 2000, but gradually decreased to only one exceedance in year 2004. The number of daily maximum exceedances increased to 6 days at the Fountain Hills and Rio Verde sites in 2005, but decreased to 4 days at the North Phoenix site in 2006. There were no exceedances at any site in 2007. The average frequency of exceedances for all monitoring sites within the MNA for the last 8 years (2000-2007) was 1.31 days per year.

**Table 1.** Number of days exceeding 84 ppb of eight-hour daily maximum ozone

<b>Site</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>Max</b>
Apache Junction (AJ: 04-021-3001)	N/A	N/A	0	1	0	0	3	0	3
Blue Point (BP: 04-013-9702)	10	1	5	4	0	2	0	0	10
Buckeye (BE: 04-013-4011)	N/A	N/A	N/A	N/A	0	0	0	0	0
Cave Creek (CC: 04-013-4008)	N/A	2	4	2	0	0	1	0	4
Central Phoenix (CP: 04-013-3002)	1	0	1	0	0	0	1	0	1
Dysart (DY: 04-013-4010)	N/A	N/A	N/A	0	0	0	0	0	0
Falcon Field (FF: 04-013-1010)	0	2	3	1	0	0	1	0	3
Fountain Hills (FH: 04-013-9704)	4	3	5	1	0	6	3	0	5
Glendale (GL: 04-013-2001)	1	2	2	4	0	0	0	0	4
Humboldt Mountain (HM: 04-013-9508)	2	4	8	5	0	5	0	0	8
Maryvale (MV: 04-013-3006)	1	0	3	2	N/A	N/A	N/A	N/A	3
Mesa (ME: 04-013-1003)	1	0	0	N/A	N/A	N/A	N/A	N/A	1
North Phoenix (NP: 04-013-1004)	4	4	5	4	1	3	4	0	5
Palo Verde (PALV: 04-013-9993)	1	0	1	0	0	N/A	N/A	N/A	1
Pinnacle Peak (PP: 04-013-2005)	5	4	3	3	0	1	0	0	5
Rio Verde (RV: 04-013-9706)	5	0	4	2	0	6	1	0	5
South Phoenix (SP: 04-013-4003)	3	1	2	0	0	0	0	0	3
South Scottsdale (SS: 04-013-3003)	1	1	1	3	0	1	1	0	3
Super Site (SUPR: 04-013-9997)	1	1	2	0	0	0	1	0	2
Surprise (SU: 04-013-4007)	N/A	0	0	0	N/A	N/A	N/A	N/A	0
Tempe (TEMP: 04-013-4005)	1	1	2	1	0	1	1	0	2
West Chandler (WC: 04-013-4004)	1	1	2	0	0	0	2	0	2
West Phoenix (WP: 04-013-0019)	1	0	2	0	0	0	3	0	3
<b>Max</b>	<b>10</b>	<b>4</b>	<b>8</b>	<b>5</b>	<b>1</b>	<b>6</b>	<b>4</b>	<b>0</b>	<b>10</b>

**5. When eight-hour daily maxima in excess of 84 ppb occur, is there an accompanying characteristic spatial pattern, or is there a variety of spatial patterns?**

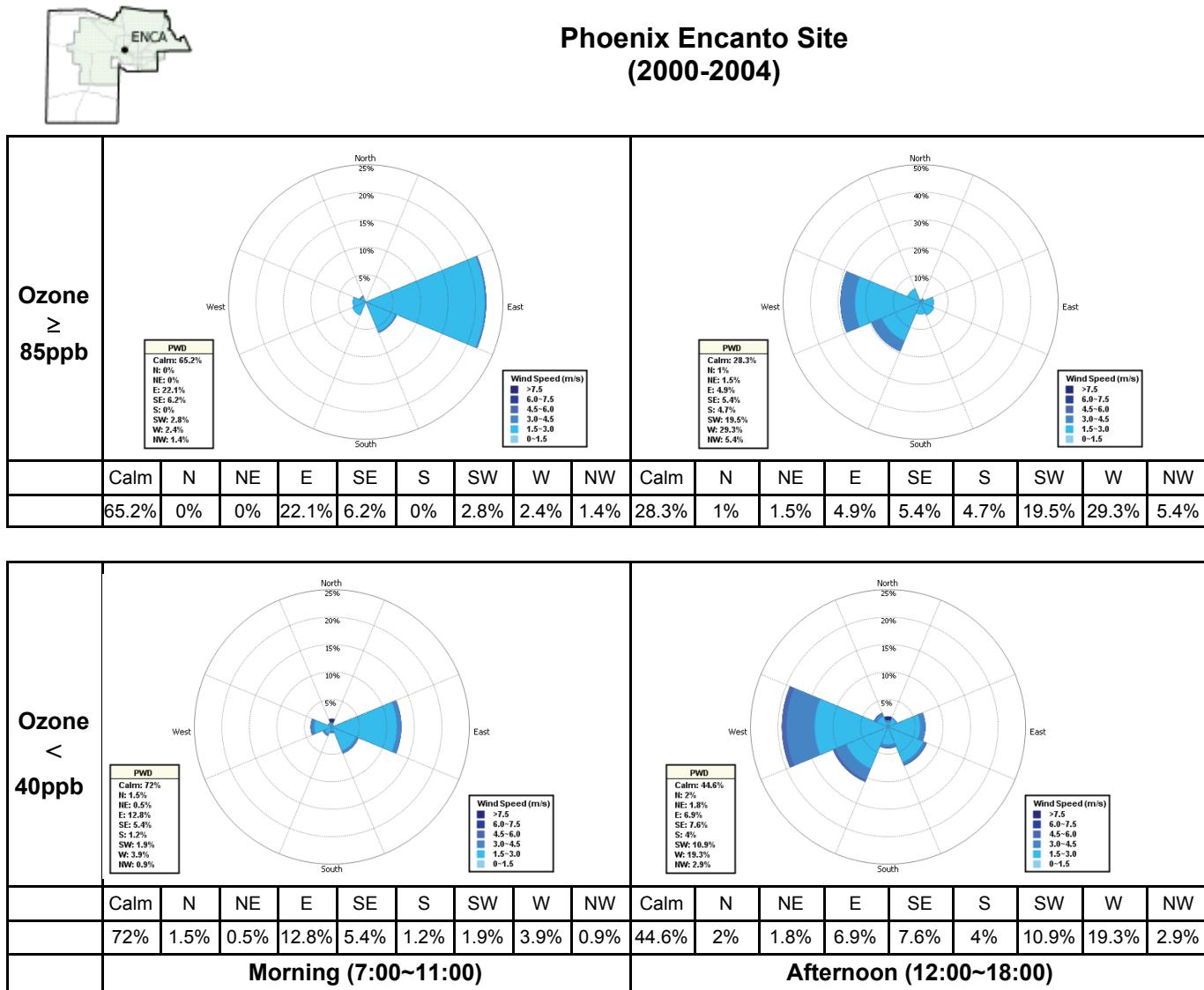
According to the spatial distribution of eight-hour daily maxima on high ozone days in Appendix D of MAG's eight-hour ozone attainment plan (MAG, 2007), a variety of spatial patterns are seen when eight-hour daily maxima in excess of 84 ppb occur. These patterns, grouped by the red lines, are summarized in Figure 4. Most exceedances occur at a small number of sites in proximity to one another in localized regions of the MNA. The exception is July 31, 2000, when two separate groups of regions appeared.



**Figure 4.** Spatial patterns of eight-hour daily maxima in excess of 84 ppb

## 6. Do monitored violations occur at locations subject to mesoscale wind patterns which may differ from the general wind flow?

Hourly surface wind direction and speed data on high and low ozone days at the Phoenix Encanto site are summarized in Figure 5. Morning winds are predominantly calm (65.2%) and easterly (22.1%) on days with eight-hour daily maximum ozone greater than 84 ppb. This is similar to morning winds on low ozone days less than 40 ppb, except calms (72%) are more frequent and easterly component winds (12.8%) are less common. Afternoon winds are predominantly SW-W (48.8%) on high ozone days. This is also similar to low ozone days, which, however, have more frequent calm periods (44.6%) than SW-W (30.2%). The MNA has an apparent morning (easterly) and afternoon (westerly) surface wind pattern that is most likely influenced by the topography of the basin, indicating that large (or “synoptic”) scale forcings are weak in the area.



**Figure 5.** Wind roses for morning (7:00-11:00 MST) and afternoon (12:00-18:00 MST) hours on high and low ozone days at the Phoenix Encanto site (2000-2004)

**7. Have there been any recent major changes in emissions of VOC or NOx in or near the nonattainment area? If so, what changes have occurred?**

NOx and VOC emissions data for the MNA were provided by the Maricopa County Air Quality Department (MCAQD, 2004 and 2008). Table 2 summarizes total anthropogenic emissions for point, area, nonroad, and onroad mobile sources, as well as biogenic emissions, for a typical ozone season day in the MNA in 2002 and 2005. Figure 6 depicts the percentage contribution of each anthropogenic emission source category.

**Table 2.** Summary of ozone season-day emissions by category in the MNA (tons\*/day)

Source Category		Inventory Year	
		2002	2005
Point	NOx	12.05	11.18
	VOC	14.56	13.28
Area	NOx	12.38	22.62
	VOC	113.44	126.78
Nonroad	NOx	74.76	89.59
	VOC	46.91	77.00
Onroad Mobile	NOx	199.87	174.67
	VOC	82.96	94.13
Total Anthropogenic	NOx	299.06	298.06
	VOC	257.87	311.19
Biogenic	NOx	6.94	4.99
	VOC	46.01	248.82

\* Denotes short ton.

Table 2 indicates that anthropogenic NOx emissions decrease slightly (0.3 percent), while anthropogenic VOC emissions increase by 20.5 percent between 2002 and 2005. The changes in anthropogenic emissions occurred at the same time residential population in Maricopa County increased by 11.4 percent. Most of the increase in anthropogenic VOC emissions is attributable to improvements in the inputs to the 2005NONROAD model and the MOBILE6.2 and M6LINK onroad mobile source emission models.

Although three new power plants began operations in or near the MNA between 2002 and 2005 (see Table 3), Table 2 indicates that point source emissions decrease between 2002 and 2005. Thus, the addition of the new power plants did not exert a major impact on point source emissions.

In addition, biogenic emissions increased by more than 400 percent between the 2002 and 2005 emission inventories. The substantial increase in the 2005 biogenic VOC emissions

is due to the application of a new biogenic model (MEGAN) with updated emission rates based on field measurements of local vegetation.

Therefore, there have been no recent major changes in NOx emissions. Anthropogenic VOC emissions in the MNA increased, which may be attributed to changes in modeling assumptions, as well as residential population growth. Although biogenic VOC emissions are much higher in 2005, this is due to the improved MEGAN model and local emission rates, rather than changes in land use.

**Table 3.** Power plants operating in Maricopa County

Power Plant	2002	2005
APS West Phoenix Power Plant	✓	✓
Duke Energy Arlington Valley	✓	✓
New Harquahaha Generating Co.		✓
Mesquite Generating Station		✓
Ocotillo Power Plant	✓	✓
Gila River Power Plant		✓
Redhawk Generating Station (Pinnacle)	✓	✓
Santan Generating Plant	✓	✓
SRP Agua Fria Generating Station	✓	✓
SRP Kyrene Steam Plant	✓	✓

### Maricopa County: NOx Emissions Season-day



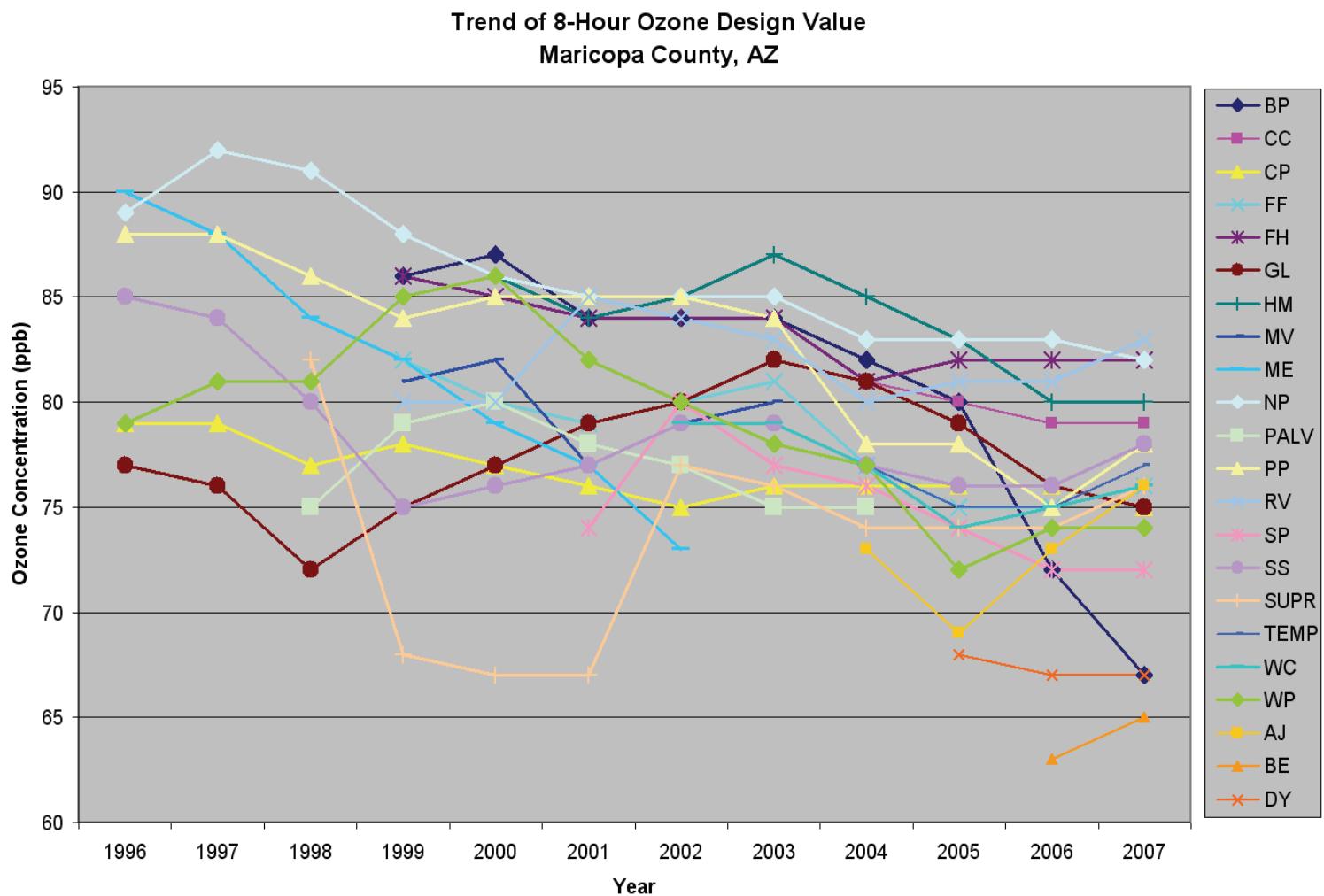
### Maricopa County: VOC Emissions Season-day



**Figure 6.** Summary of 2002 and 2005 ozone season-day NOx and VOC emissions by major anthropogenic source categories in the MNA

## 8. Are there discernible trends in design values or other air quality indicators which have accompanied a change in emissions?

Figure 7 shows the 1996-2007 trend in the design values (three consecutive years' average of annual fourth highest daily maximum eight-hour average concentration) at monitoring sites in the MNA. In general, the trends are similar for many sites, with values gradually decreasing to a minimum in 2004 or 2005, and remaining at similar levels ( $\pm 3$  ppb) thereafter. An exception is the trends at the Blue Point, Glendale, Humboldt Mountain, and South Phoenix monitoring sites, which continued decreasing at a relatively fast rate after 2004, and reached their minimum levels in 2007. In contrast, the design value at the Apache Junction site increased 7 ppb from 2005 to 2007. Another observation is that before 2002 the highest design value occurred primarily at the North Phoenix site and then shifted to the Humboldt Mountain site between 2002 and 2005.



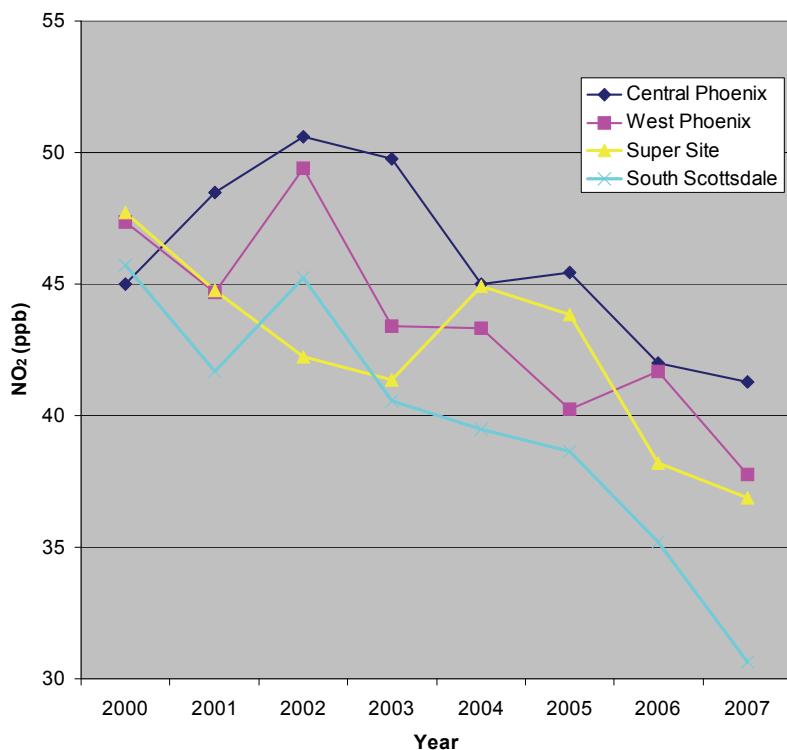
**Figure 7.** Trends in eight-hour ozone design values at Maricopa County monitoring sites: 1996-2007

## **9. Is there any apparent spatial pattern to the trends in design values?**

There was no apparent spatial pattern in the trends in design values before 2004, when most sites underwent downturn changes. There was a discernible spatial pattern between 2004 and 2007. As shown in Section 8, the design values of many sites located in the Phoenix urban core remained at similar levels during this time period (e.g., Central Phoenix, North Phoenix, West Phoenix, Super Site, South Scottsdale, and Tempe monitoring sites). The sites outside the urban core generally underwent larger changes (e.g., South Phoenix, West Chandler, Pinnacle Peak, and Rio Verde monitoring sites). The sites at locations far removed from the urban core experienced even larger changes (e.g., Blue Point, Glendale, and Humboldt Mountain monitoring sites).

## **10. Have ambient precursor concentrations or measured VOC species profiles changed?**

NO<sub>x</sub> monitors (NO and/or NO<sub>2</sub>) have been co-located with ozone monitors at nine sites in the MNA. Four sites - Central Phoenix, West Phoenix, Super Site, and South Scottsdale - were selected for this analysis based on their complete data records during the ozone season. Data from these monitors provide an opportunity to examine the trends in NO<sub>x</sub> in the Phoenix urban core. Figure 8 depicts the annual average of daily maximum NO<sub>2</sub> during the ozone season from 2000 to 2007. All four sites showed a downward trend in NO<sub>2</sub> concentrations from 2000 to 2007.



**Figure 8.** Annual average of daily maximum NO<sub>2</sub> during the ozone season from 2000 to 2007

## **11. What past modeling has been performed and what do the results suggest?**

A nested CAMx modeling was performed for the eight-hour ozone attainment plan, with the nested inner domain encompassing the MNA (MAG, 2007). A total of three ozone episodes were simulated, which were June 3-7, 2002; July 8-14, 2002; and August 5-11, 2001.

Sensitivity tests indicated that the simulated ozone was highly sensitive to boundary conditions. The sensitivity tests demonstrated that transport of ozone and ozone precursors were not major contributors to ozone levels for the majority of the ozone episode days modeled. However, for one episode, June 2002, ozone and ozone precursors transported from outside the MNA contributed 48%-63% to the high ozone levels, while the transport contribution was smaller for the July 2002 and August 2001 episodes. The contribution of the transport of ozone and ozone precursors to high ozone levels was adequately addressed in the modeling through use of the outside 12 km grid modeling domain.

It should be noted that the contribution of background ozone to the highest design value in the MNA is generally less than 55 ppb ( $0.63 * 87$  ppb), which implies that the transport of ozone at concentrations approaching 84 ppb is unlikely, and therefore, the cause of the MNA's eight-hour ozone exceedances are primarily due to local factors. As such, the modeling results are consistent with the conclusions of Section 1.

Additional sensitivity tests that varied emissions by source category showed that the simulated ozone is most sensitive to onroad mobile emissions and least sensitive to point source emissions. Further sensitivity tests were made by removing anthropogenic emissions of NOx and VOC separately. The analysis revealed that ozone concentrations increased with NOx reductions in the urbanized portion of the nonattainment area.

## **12. Are there any distinctive meteorological measurements at the surface or aloft which appear to coincide with occasions with eight-hour daily maxima greater than 84 ppb?**

There is no obvious correspondence between eight-hour ozone maximums and meteorological measurements other than that high ozone levels are associated with daily maximum temperatures that are at least 89 F and surface winds that are easterly in the morning.

**References:**

Maricopa Association of Governments, (2007), "Eight-Hour Ozone Plan for the Maricopa Nonattainment Area".

Maricopa County Air Quality Department, (2004), "2002 Periodic Emission Inventory for Ozone Precursors".

Maricopa County Air Quality Department, (2008), email from Downing, B., "2005 Periodic Emission Inventory for Ozone Precursors".

U.S. EPA, (2007), "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze", EPA-454/B-07-002.